

National Exams May 2010

07-Elec-A5, Electronics

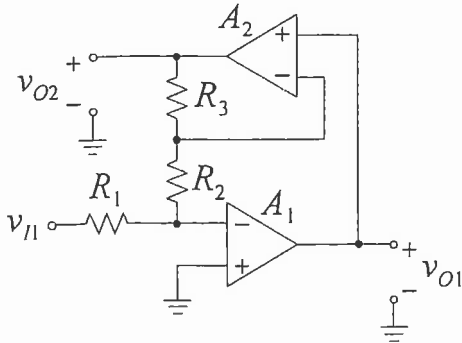
3 hours duration

Notes:

1. If any doubt exists as to the interpretation of any question, the candidate is urged to submit, within their answer, a clear statement of any assumptions made.
2. This is a CLOSED BOOK EXAM.
A Casio or Sharp approved calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.
The first five questions as they appear in the answer book will be marked.
4. All questions are worth 20 marks each.
5. Please start each question on a new page and clearly identify the question number and part number, e.g. Q4(a).
6. In schematics, ground and chassis may be assumed to be common, unless specifically stated otherwise.
7. Unless otherwise specified, assume that Op-Amps are ideal and that supply voltages are $\pm 15V$.
8. Some questions require an answer in essay format. Clarity and organization of the answer are important. Provide block diagrams and circuit schematics whenever necessary.

QUESTION (1) a) Derive an expression for the output v_{O1} and v_{O2} as a function of R_1 , R_2 , R_3 , and v_{I1} in the following op amp circuit. (14 points)

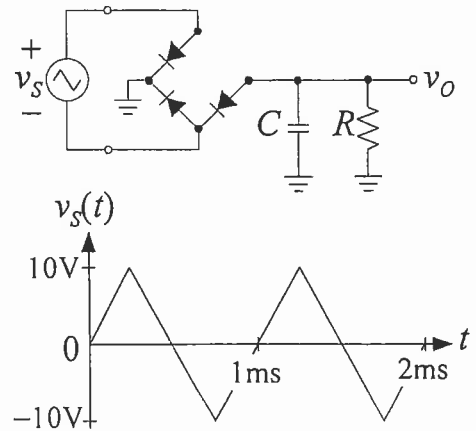
b) Provide a possible set of values for R_1 , R_2 , R_3 , such that $|v_{O2}/v_{I1}|$ has a gain of 20 V/V. (6 points)



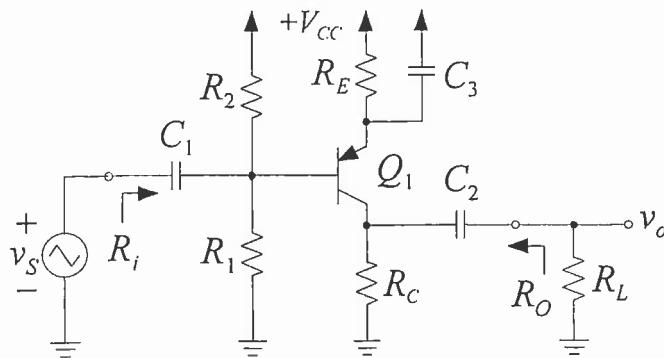
QUESTION (2)

One of the diodes in this full-wave rectifier is damaged. As a result, only three diodes are working. Assume that the diodes are ideal with zero forward voltage drop and that the time constant $RC = 100$ ms. For a 1 kHz triangular input waveform with a peak amplitude of 10V, and using the assumption that $RC \gg T$,

- Sketch accurately in your answer book the output voltage waveform, v_O . (4 points)
- What is the peak voltage, V_p and the ripple voltage V_r that would appear at the output? (8 points)
- What is the average output voltage at v_O ? (4 points)
- Estimate the time interval, t_{on} during which the diodes conduct during each period. (4 points)



QUESTION (3)



Assume that the BJT has the following characteristics:

- $\beta = 100$
- $V_{EB(on)} = 0.7V$
- $V_{EC(sat)} = 0.3V$
- $V_A = \infty$

Given: $V_{CC} = 10V$, $R_L = 10k\Omega$, and $R_E = 1k\Omega$,

a) Design this common emitter amplifier circuit to have the following specification:

- DC bias current, $I_E = 2mA$,
- A mid-band voltage gain $v_{out}/v_s = 100 V/V$
- Provide values for R_1 , R_2 , and R_C .

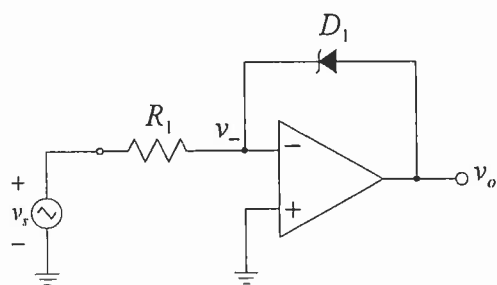
(15 points)

b) What is the equivalent output resistance, R_O ?

(2 points)

c) What is the maximum undistorted peak to peak output voltage swing at the output? (3 points)

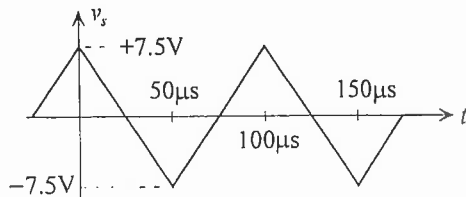
QUESTION (4)



The op amp in this circuit is ideal except for a slew rate limit of $0.5V/\mu s$. It is powered by $\pm 15V$ supplies. Given that

- $R_1 = 10k\Omega$
- For D_1 , $V_Z = 5V$, forward voltage drop = $0.7V$

Sketch **accurately** in your answer book the voltage waveform for v_o . You must indicate the breakpoints, including accurate timing and voltage levels. (20 points)



QUESTION (5)

Transistor M_1 in this circuit has the following characteristics:

$$V_{TH} = 1 \text{ V} \quad \lambda = 0.01 \text{ V}^{-1}$$

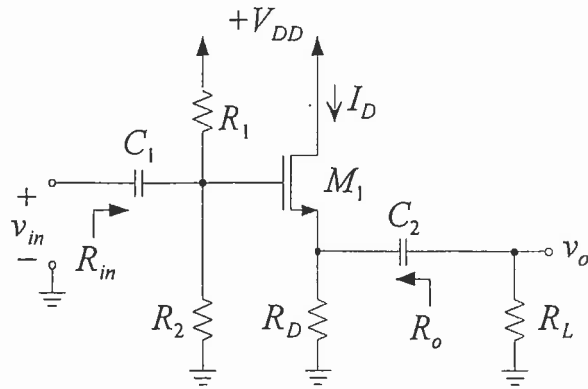
$$K = 2 \text{ mA/V}^2$$

Given:

$$V_{DD} = 10 \text{ V,}$$

$$R_L = 10 \text{ k}\Omega \text{ and}$$

$$C_1 = C_2 = \infty$$



a) Design this circuit to have the following specifications:

$$R_{in} = 100 \text{ k}\Omega, I_D = 2 \text{ mA}$$

Provide values for R_1, R_2 and R_D . |

(12 points)

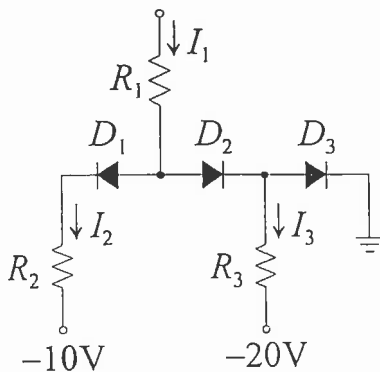
b) Determine the output resistance, R_o .

(4 points)

c) Determine the maximum undistorted peak to peak output voltage?

(4 points)

QUESTION (6) Solve for the currents I_1, I_2 , and I_3 in the following diode circuit. (20 points)



Given:

All diodes are ideal with 0.6V forward drop

$$R_1 = R_2 = R_3 = 10 \text{ k}\Omega$$